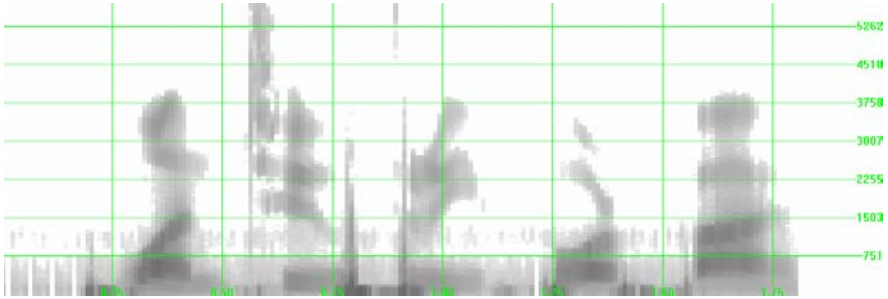
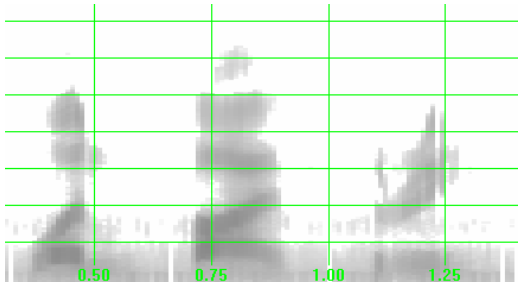


Sensory Transduction Interfaces

Jeff Norris

Interaction Lab Research Summary

Wednesday, September 3, 2003



Sensory Transduction (ST)

ST is the conversion of one form of sensory data into another.

- Dr. Paul Bach-y-Rita of the University of Wisconsin has demonstrated that the brain is capable of correctly interpreting sensory data when it arrives via a different sensory pathway.
  - Visual, tactile, vestibular, and auditory data can be conveyed via electro-tactile stimulation of the skin.

- ST has many exciting applications:
  - Sense restoration for the disabled
  - Augmentation of existing human senses
  - Direct sensation of complex systems
- ST fundamentally depends upon ST functions, which map data from the domain of one sense into the range of another.
  - This research is focused on the rigorous definition and evaluation of ST functions and their application to a variety of problems.

Sensory Transduction (ST) Functions

ST functions map data from one sense to another.

$$y_j = T_{ij}(x_i)$$

y_j = converted data for "ouput" sense *j*.

transduction function from sense *i* to *j*

x = original data from "input" sense *i.*

- Among the 3 "high bandwidth" senses (visual, auditory, and tactile) there are up to 9 transduction functions (n^n).
- These 9 functions could be reduced to 3 if
  - each T_{ij} is decomposable into independent encoding and decoding functions E_i and D_j: $y_j = D_j(E_i(x_i))$ and
  - each D_i can be expressed as the inverse of E_i: $D_i = E_i^{-1}$
- Such reducibility, if it exists, would have interesting implications.
  - Suggests a source-independent "meta-format" for sensory data.
  - Reduces the problem of encoding arbitrary data for any sense to the problem of encoding that data in this meta-format.

Research Status and Directions

Currently focused on problem definition and basic tests.

- Approaching final definition of research problem.
- Exploring potential collaborations with USC Health Sciences.
- Tentative research approach:
  - Study human sensory pathways to gain an understanding of the expected domain and range of the ST functions.
  - Choose two senses *i* and *j* and develop ST functions T_{ij} and T_{ji}.
  - Attempt to reduce T_{ij} and T_{ji} to two encoding/decoding functions and a meta-format, comparing their performance to the above.
  - Repeat the process with the addition of the remaining sense.
  - Use the ST functions to develop and evaluate basic assistive systems for blind, deaf, or paralyzed persons.
  - Investigate the use of the ST functions with other sources of data and application areas to evaluate their generalizability.